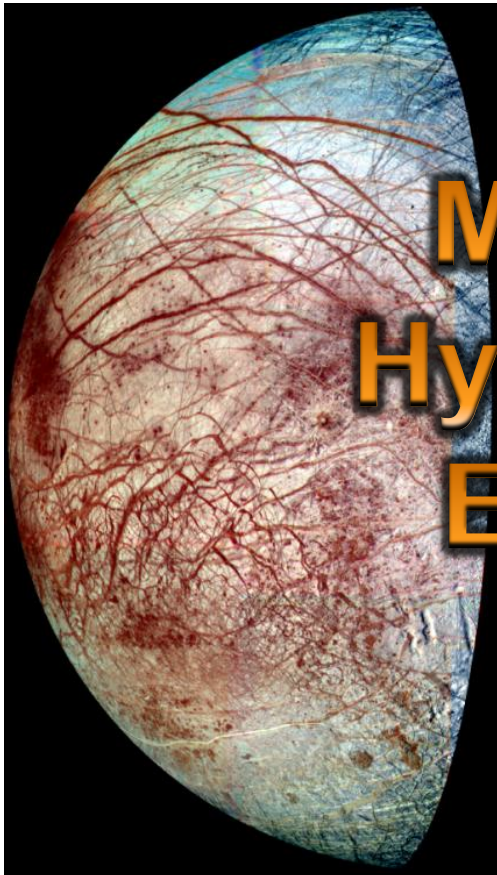
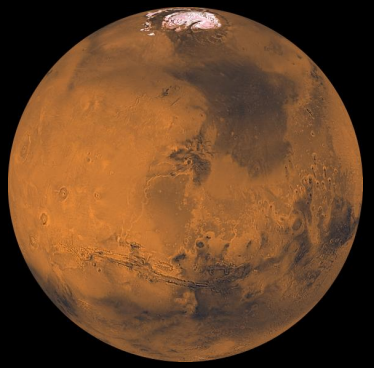


Magnesium Sulfate Hydrates on Mars and Europa: A Spectral Investigation



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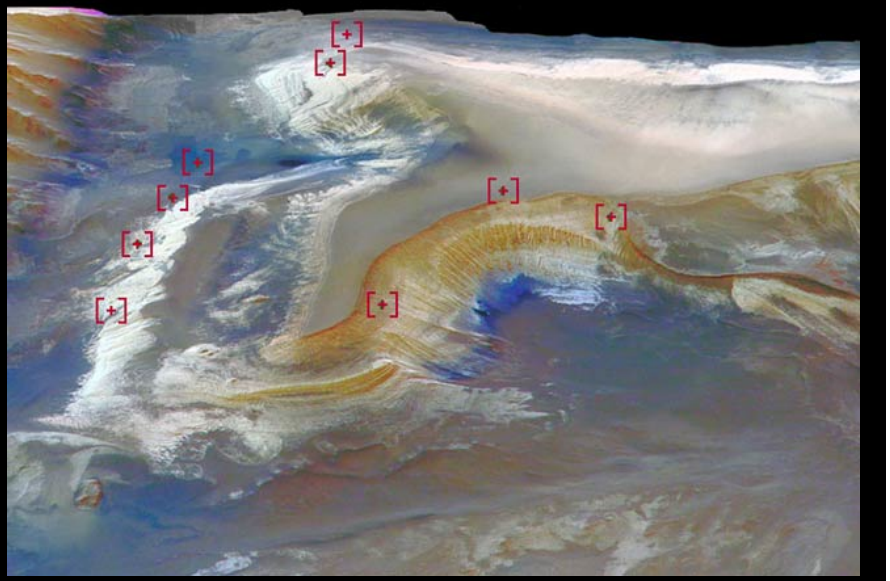
Motivation

- Remote sensing observations inherently represent a combination of chemical species
- Quantification of individual components requires mixture models using laboratory spectra measured at appropriate conditions
- Spectra of many chemical species are altered by temperature, grain size and other matrix effects

The Magnesium Sulfate Series

- Multiple hydration states exist:
  - 0, 1*, 1.25, 1.5*, 2, 3, 4*, 5, 6, 7*, 11
- Hydrated magnesium sulfate salts are considered to be important components of the Martian and European su

Magnesium sulfate - rich stratified deposits identified by OMEGA

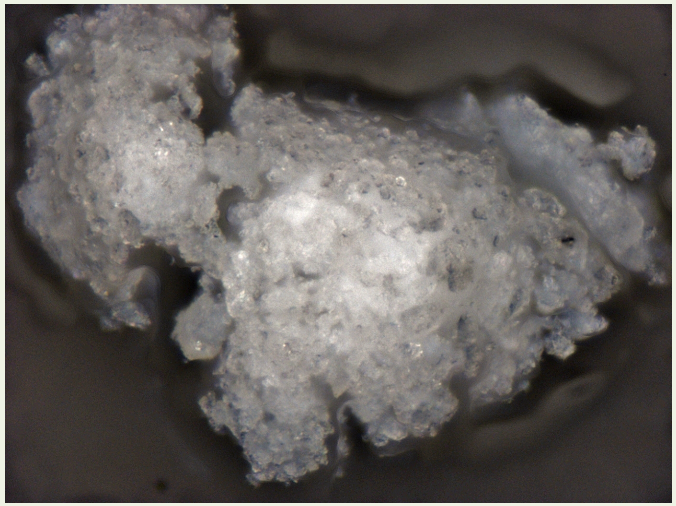


- Kieserite ($MgSO_4 \cdot H_2O$), has been confirmed on Mars and is predicted on Europa

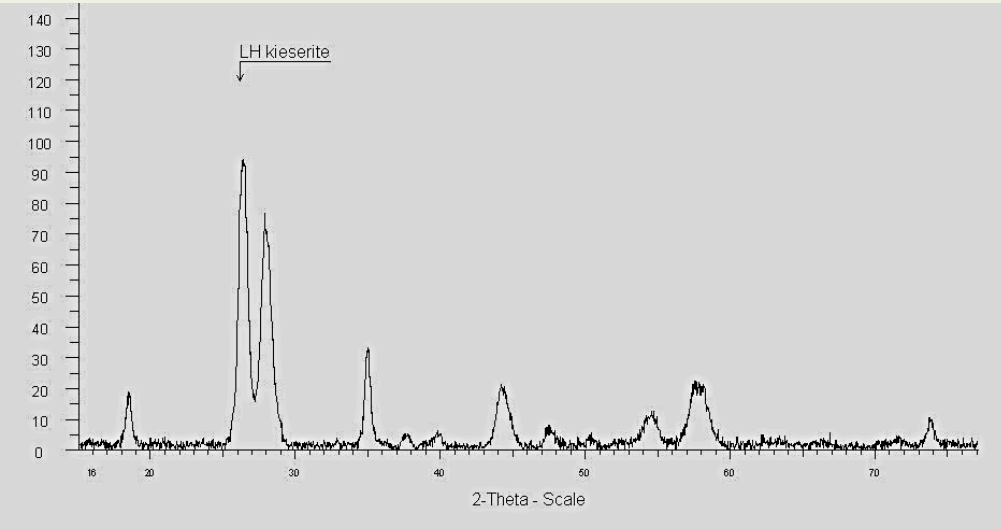
Experimental Approach

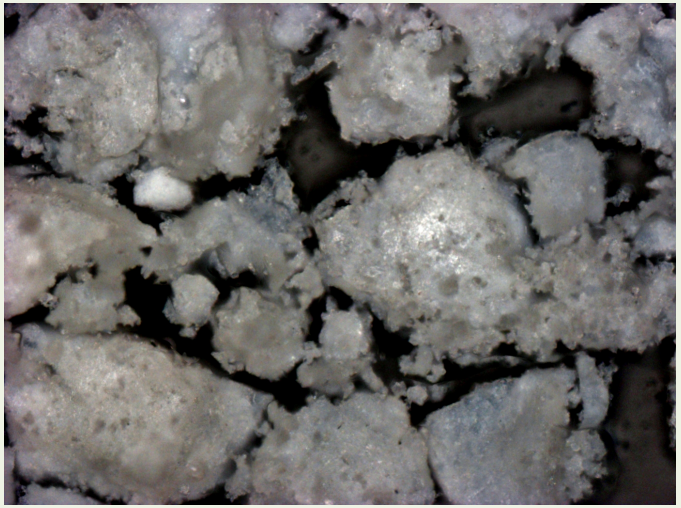
- Utilize Vis-NIR spectroscopy in combination with diffuse reflectance FTIR spectroscopy
- Basic Extraterrestrial Environment Simulation Testbed (BEEST) can achieve a temperature range of 10K-330K and pressures down to 10^{-9} torr while recording diffuse reflectance spectra from 0.35-25 microns.
- Samples also characterized with cryogenic temperature controlled optical microscopy and XRD

Preparation of kieserite ($MgSO_4 \cdot 1H_2O$)

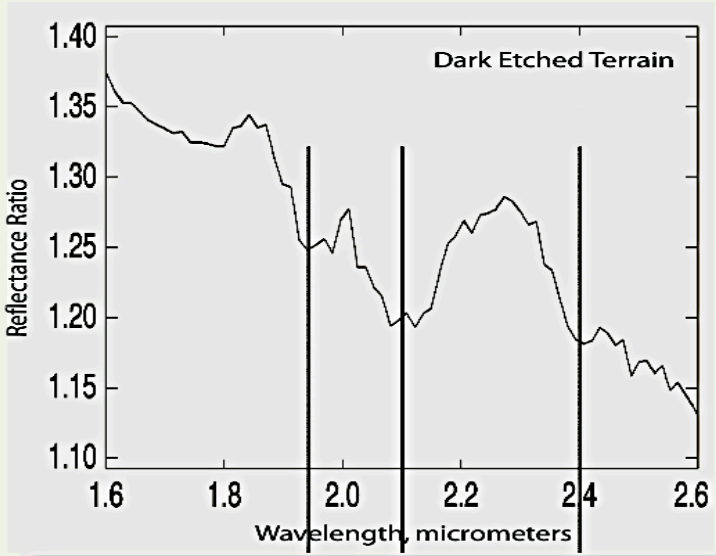


- Synthesized kieserite through dehydration of epsomite to form the low humidity polymorph.
- Molecular composition confirmed by x-ray diffraction (XRD)
- Grains were sieved and their size verified by visual inspection using a cryogenic optical microscope

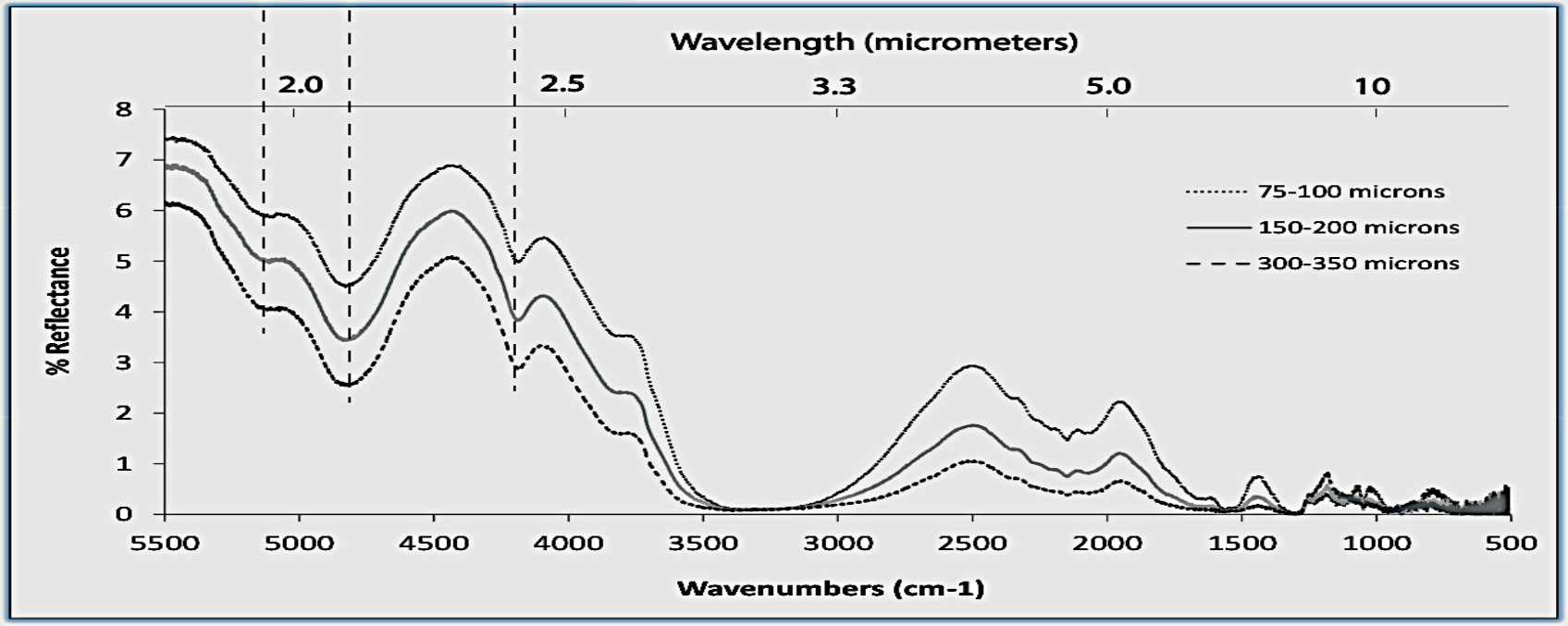




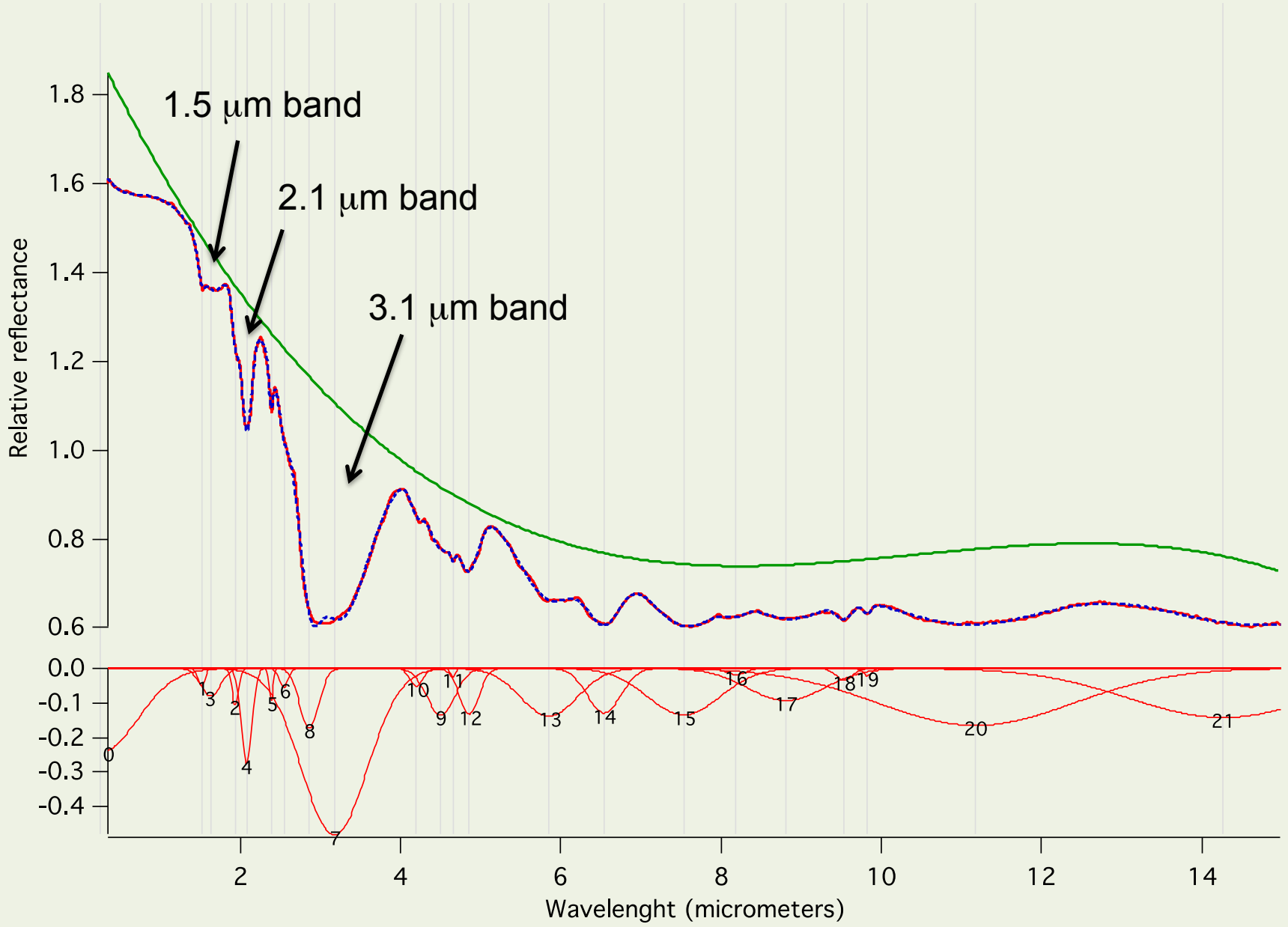
Kieserite ($MgSO_4 \cdot 1H_2O$) on Mars



- Kieserite has been identified in the surface spectra of Mars taken by the OMEGA instrument
- If grain size effects are known, additional information can be extracted and confidence in assignments is improved

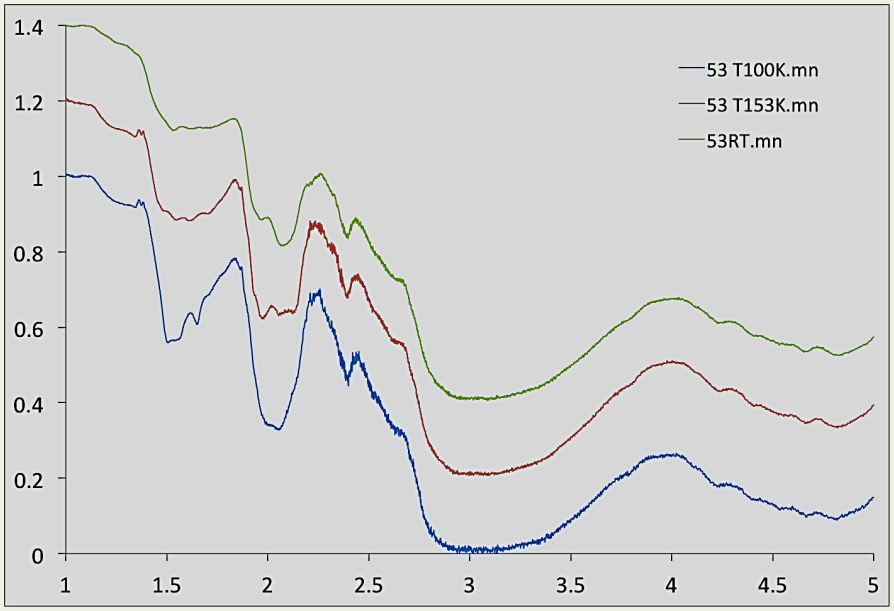


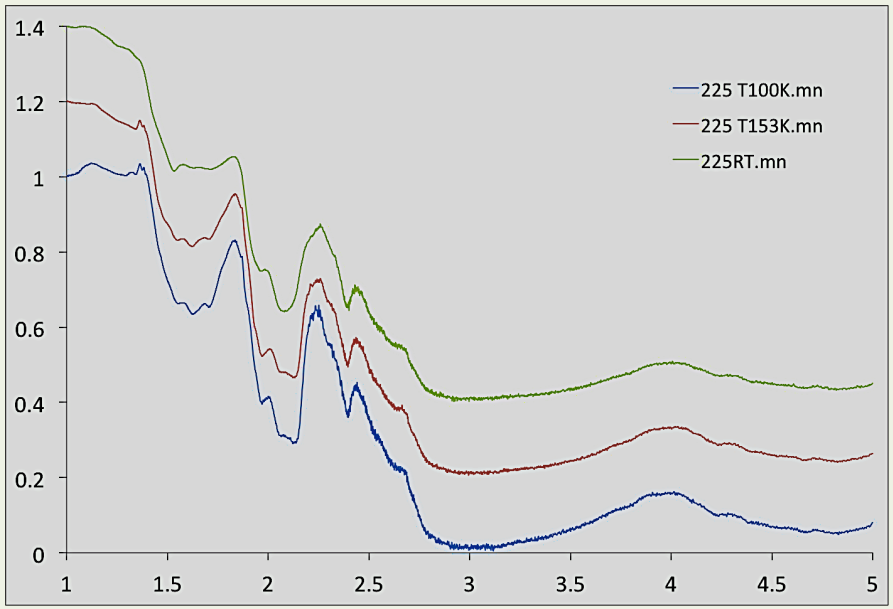
Reflectance Spectrum of 53-75 μm Kieserite

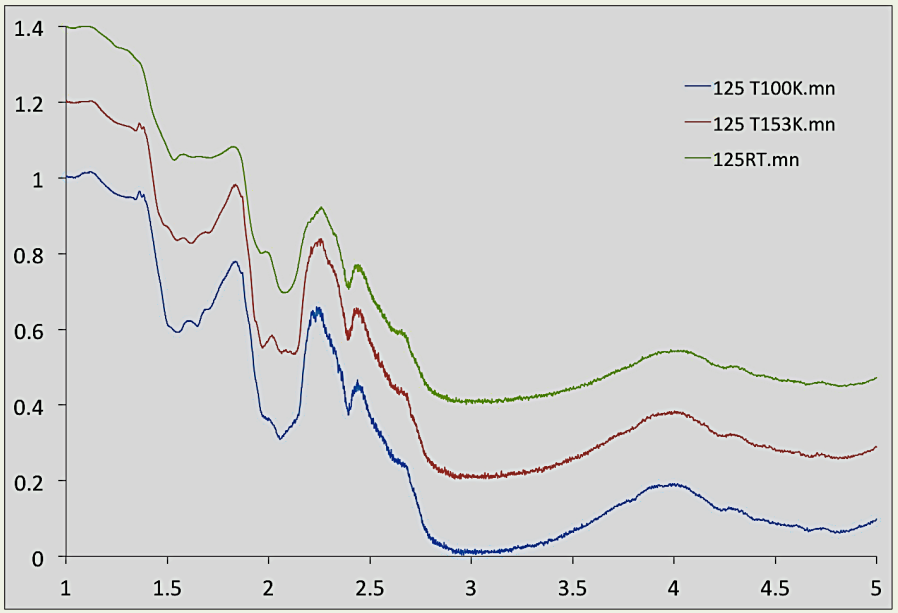


Temperature variable, grain size constant

- The 1.5 and 2.1 micron regions resolve into discrete bands as the temperature is lowered
- The 3.1 micron band is largely unaffected by temperature variations

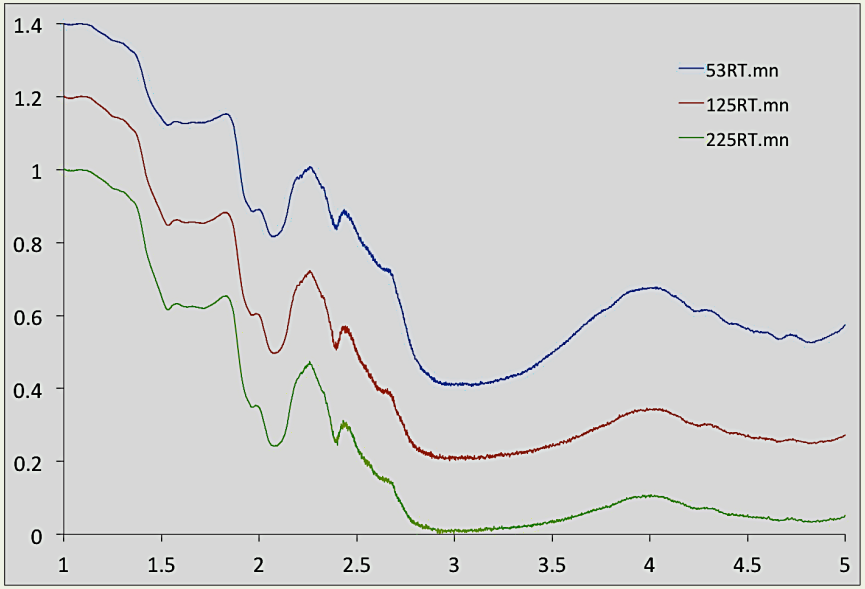


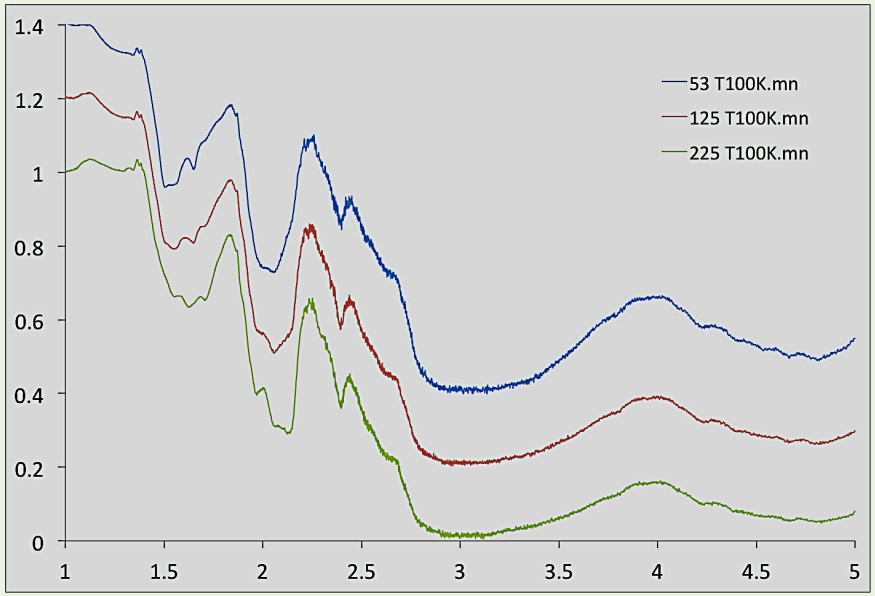


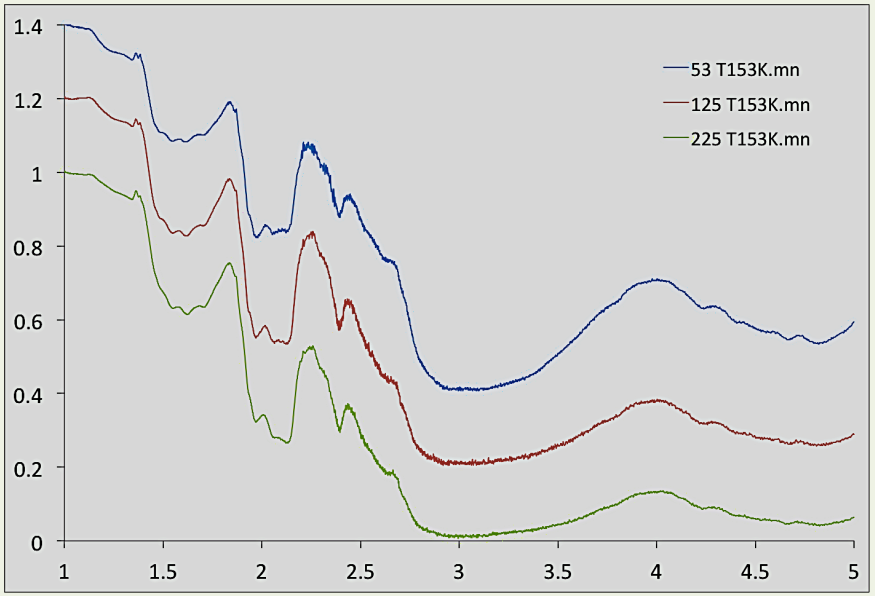


Grain size variable, temperature constant

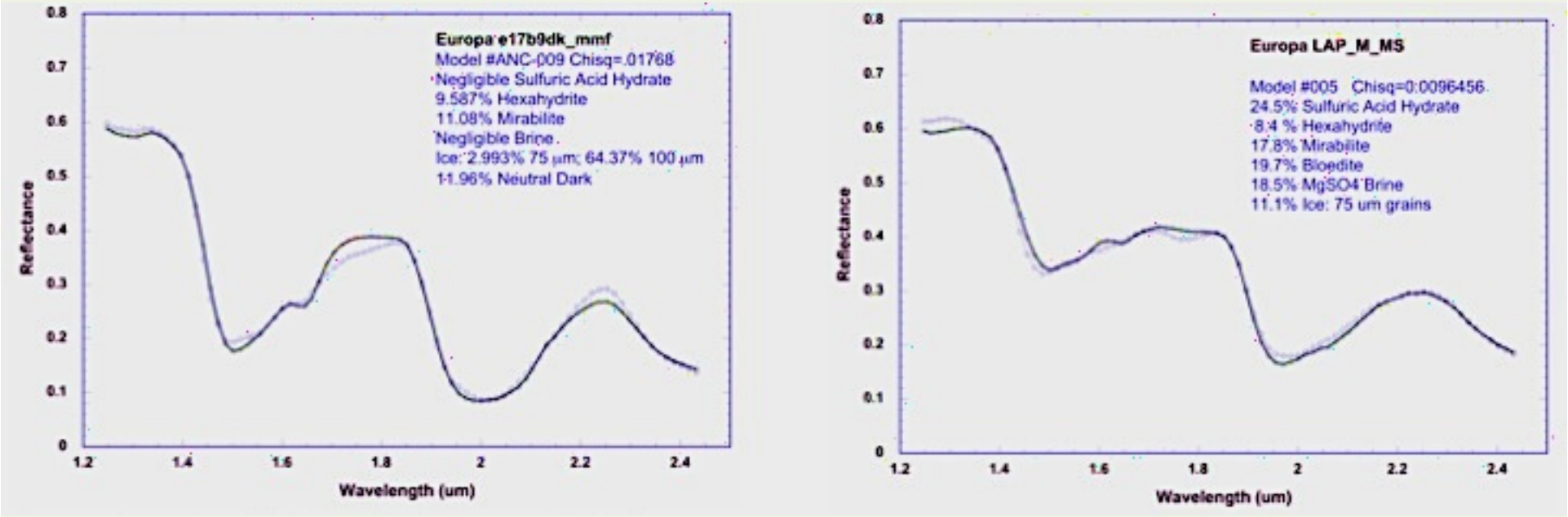
- The 1.5 and 2.1 micron regions are altered more by a change in temperature than grain size
- The width and depth of the 3.1 micron band is sensitive to grain size







Europan surface composition



Dalton et al., LPSC 2011

Current linear mixture models of the Europan surface composition have done a very good job at identifying primary components. However, the fits are not perfect and many details remain hidden due to the inherent difficulty in modeling intimate mixtures and **a lack of appropriate laboratory spectra** as inputs.

Summary

- We must gain a better understanding of how the physical conditions and formation routes affect the chemical spectra

- This is a key step in the interpretation of imaging spectrometer data and for mapping distributions of magnesium sulfates on the surfaces of Mars and Europa

- Goal to develop intimate mixture models to constrain molecular abundances on the surfaces of Mars and Europa, which will provide a better picture of chemical formation and evolution and associated geologic processes